

EDUCATION AND RECRUITMENT OF ENGINEERS
FOR WORK IN AVIATION ARMAMENT

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ABSTRACT

In recent years, naval laboratories have experienced a serious shortage of engineers properly qualified for work in aviation armament. To investigate problems relevant to the education and recruitment of engineers for such work, this study considers the extent to which aircraft armament contractors have experienced a shortage of engineers for armament work, the type of educational background desired for such work, recruitment procedures and inducements to accept government employment, the desirability of graduate education, and the extent of financial assistance to be provided for advanced academic work.

Information for this thesis was obtained principally from an extensive search of the literature, an industrial survey questionnaire, and interviews with educators and participants in government graduate education programs. Much of the desired information could be obtained only from a questionnaire answered by representatives of aviation armament contractors and related agencies, and the number of such organizations is limited. However, approximately 50 per cent of 85 organizations contacted returned usable questionnaires, and a high proportion of these responses were from large contractors in the armament field. As a result, the study presents reliable information which, it is felt, expresses the current thinking of the aviation armament industry.

It was concluded from this study that a shortage of engineers qualified for work in aviation armament exists, and that it occurs in respect both to quantity and quality. A broad undergraduate engineering background was found to be desired, but graduate education should be specialized. Ideally, for work in aviation armament, a good foundation is desired in electricity, physics, and mathematics, and at least some knowledge is desired of servo mechanisms, control devices, structures, aerodynamics, electronics, and ballistics.

Direct campus recruitment by government agency representatives is much less effective than that of industrial representatives and should be improved. Similarly, literature describing government employment opportunities should be improved.

It was also found that graduate education of engineers for work in aviation armament is definitely desirable, but that it should follow several years' practical experience. The opportunity to participate in graduate education programs leading to advanced degrees does help to attract and retain engineers of promise and ability, but engineers to be offered full time graduate education should be selected carefully. Finally, it was concluded that naval activities should contribute substantially to the costs of graduate education programs in order to provide employment opportunities competitive with those of industry.

As a result of this study, it is recommended that every effort be made to recruit engineers with a broad undergraduate background and having knowledge of as many of the following sciences as possible: electricity, physics, mathematics, servo mechanisms, control devices, structures, aerodynamics, electronics, and ballistics.

Only carefully selected representatives should be used for direct campus recruitment, and these representatives should be trained in the use of effective recruiting techniques. Literature describing government employment opportunities should be examined to insure effective distribution, readability, and effective communication of content. It is also recommended that applications for government employment, when received, should be processed promptly.

Finally, it is recommended that naval activities offer graduate education programs to the maximum extent possible. In certain cases, it is desirable that engineers selected for such programs be granted leave for full time study at selected universities. In all cases, naval activities should expect to pay a substantial portion of the costs of graduate education programs.

EDUCATION AND RECRUITMENT OF ENGINEERS
FOR WORK IN AVIATION ARMAMENT

INTRODUCTION

The Armament Division of the Bureau of Aeronautics, Department of the Navy, has experienced increasing difficulty in recent years in recruiting engineers properly qualified for work in aviation armament. Experience in Bureau laboratories has indicated that, to be most effective, such engineers should have basic academic training which cuts across the boundaries of traditional engineering courses. Consequently, it is felt that no present graduate of a college, either of engineering or physics, has received adequate training in all of the fundamentals which he should possess in order to do this work*.

It is possible to find older people who have acquired some of the background for work in aviation armament through experience. However, in the recruitment of these people it has been found that if they are capable, they are seldom interested in government work since they are in such high demand by industry that they receive far better compensation there. Also, as a result of limitations imposed by the Civil Service classification system, government agencies cannot continually recruit upper grade people who have acquired

*The problem as here stated essentially expresses the opinions of Dr. L. H. Glassman, technical assistant to the Director of the Armament Division.

some measure of training by experience and would be interested in employment only at the upper levels. Younger engineers in the 21-28 age bracket are required in fundamental research, in applied research, in research and development, and in production.

This thesis investigates the extent to which these problems of the Navy are experienced by armament contractors and related agencies, and seeks solutions to the problem of obtaining young engineers qualified for work in aviation armament at naval activities. Where problems of the Navy are common with those of industry, solutions of value to both are sought. In certain areas such as recruitment, however, consideration is given to problems essentially peculiar to government employment.

Purpose

The purpose of this study, then, is to investigate problems relevant to the education and recruitment of engineers for work in aviation armament. Specifically, this study seeks to accomplish the following objectives:

1. Determine the extent to which aircraft armament contractors have experienced a shortage of young engineers for work in aviation armament.
2. Investigate the types of educational background which best prepare engineers for work in aviation armament.
3. Study recruitment procedures and inducements which may be effective in persuading promising engineers

to accept government employment, as opposed to employment in industry.

4. Investigate the desirability of graduate education to assist in qualifying engineers for work in aviation armament, and to induce them to accept government employment.

5. Determine the degree of assistance which should be provided promising engineers selected for advanced academic work.

Stated generally, these problems are all of vital importance to many government agencies and obviously are not confined only to the Navy's aeronautics organization. Realization that they are not unique, however, does not obviate attempts to find solutions in specific applications. The fact that government competes with industry for available professional talent states only part of the problem faced by managers of government agencies in recruiting suitable personnel; American colleges and universities simply do not produce, nor should they attempt to produce, graduates adequately trained for all requirements of government and industry. Therefore, certain organizations must provide additional education which will best qualify their professional employees to perform the work required.

To investigate problems relevant to the education and recruitment of engineers qualified for work in aviation armament, it is intended in this thesis to consider individually each of the objectives stated previously. It must

be borne in mind, however, that these objectives constitute a somewhat arbitrary breakdown of the overall problem, and that they are all closely related. Problems of administration, which affect the satisfaction of the engineer with the job situation after he has accepted employment, will not be considered. Although meriting considerable attention, this is a separable problem from that of recruiting engineers for armament work, and one on which much has already been done*.

Sources of Data

Information presented herein is from several sources. First, an extensive search of the literature was carried out. This revealed those areas in which little or no published material is available, and for which other sources of information had to be sought. For example, extensive literature is available on the problem of effective recruitment, whereas, as might be expected, no literature considered the types of educational background desired for engineers to work in aviation armament. It was felt that this latter information could properly come only from representatives of organizations actively engaged in such work. Consequently, the second source of information for this thesis is an industrial survey questionnaire.

The number of agencies actively engaged in what can

*See, for example, references 1, 2, and 6 from the list of General References, page 51.

legitimately be claimed as aircraft armament, employing engineering staffs of sufficient size to furnish useful information for a thesis report, is limited. However, a list of contractors active in the armament field was furnished by the Navy Bureau of Aeronautics as a possible source of desired information. A final group of 85 agencies was contacted with the questionnaire, as follows: 71 industrial organizations, 7 government agencies, and 7 universities. Forty useable replies were received from all agencies contacted, or 47 per cent. Information relative to the construction of the questionnaire, copies of the forwarding cover letters and the questionnaire itself, together with an analysis of the results of the survey, are all presented in the Appendices.

It was intended that the questionnaire should provide information relative to four of the five thesis objectives stated previously; namely: the extent to which contractors have experienced a shortage of engineers for armament work, desired educational background, desirability of graduate education, and the desired degree of assistance to be provided for advanced academic work. The subject of recruitment procedures and inducements to accept employment was felt to be one on which respondents would be reluctant to comment freely, and which is rather thoroughly covered in the literature. Therefore, it was omitted in the questionnaire. In the presentation which follows, results of the

questionnaire will be discussed only as they relate to the objective currently being considered.

A third source of information for this thesis is comprised of studies of graduate education programs at the Naval Ordnance Plant, Indianapolis, Indiana, and the Naval Research Laboratory, Washington, D. C., and also of interviews with educators at Purdue University who are familiar with programs at Purdue and elsewhere giving increased emphasis to basic engineering sciences. These sources provided a number of suggestions to improve the ability of the Navy to recruit desired professional personnel.

SHORTAGE OF ENGINEERS FOR WORK IN AVIATION ARMAMENT

That there is a significant and continuing shortage of engineers to meet the demands of industry, government, and education, needs little confirmation for most people concerned with professional manpower requirements. "Many groups are studying the needs for scientists and engineers and any conclusions that are developed must necessarily tie closely to the supply. Studies being conducted at the present time indicate that the nation is still in short supply of manpower with this type of background...." (6, p. 5)*. The results of the studies of one of these groups is presented in The Report of the Commission of Human Resources and Advanced Training (26), which discusses in considerable detail the extent of the current shortage of engineers and predicts the continuation of this shortage after considering the future supply.

The shortage of engineers, resulting in part from the increased demand for these people, has been particularly severe in many government agencies forced into an unfavorable competitive hiring position as a result of the Civil Service pay structure. Many such agencies have trouble in obtaining even mediocre personnel, to say nothing of top personnel, and have difficulty in holding them after they accept employment. Statements by Mr. James M. Mitchell,

*Numbers in parentheses refer to Cited References, pages 49, 50 and 51.

representing the Department of Defense, are pertinent:

The Department of Defense, though the nation's largest employer, still employs, in either a military or civilian capacity, less than 10 per cent of the total national supply of engineers and scientific personnel.

I would like to point out that at least half of our total professional manpower force serves the Department of Defense in a civilian capacity. As such, they are just as likely to take other jobs and leave us short-handed as are the engineers in private industry. In fact, this happens regularly, for private industry is currently paying higher salaries for qualified engineers than the government pay scale permits us to pay for the same type of work. As a result, the Department of Defense has been consistently short of qualified engineers for the past two years. A semi-annual Department of Defense report shows that despite recent civilian personnel reductions, civilian engineers are still in short supply, while an important engineering section in the Navy is running with only 75 per cent of the staff of engineers it ought to have for efficient operation. (19, pp. 20-21)

It is not surprising, then, that all but one of the respondents to the survey questionnaire concerning engineers for armament work indicated that during the past year, they experienced a shortage of engineers for such work. Studies to determine methods for more effective utilization of our limited number of engineers to help meet this shortage have been plentiful, and we are not here concerned with that problem. However, it was intended that the questionnaire should determine something of the nature of the shortage reported.

In the initial statement of the problem it was noted that the Armament Division is concerned with the requirement for inexperienced engineers in the 21-28 age bracket. Results of the survey indicate that, numerically at least,

industry desires younger college graduates and experienced engineers both more or less equally. Of those who answered this question, 30 respondents wanted both, 4 wanted principally experienced engineers, and 4 wanted younger engineers (question 5, Appendix B)*. Comments of respondents to this question indicate how the general shortage of engineers has influenced the results of the survey. Of those desiring both more or less equally, one comment states, "Normally, with a nucleus of experienced engineers, would prefer hiring younger men and bringing them up in the business. At the present time both types are in short supply." and another, "Lately have been forced to go to more experienced people." Furthermore, three of the four companies desiring experienced engineers were established during or since 1950. The fourth, established in the 1920s, commented that "recent expansion did not permit training time." We see, therefore, that most companies desire younger engineers, as does the Navy, but not to the exclusion of experienced people.

Another fact pointed out by the survey is that in armament work, the shortage is felt in respect both to quality and quantity and that it is more acute for engineers to be engaged in research (question 6, Appendix B). The number of replies from companies engaged almost wholly in research was little different from the number engaged almost wholly

*Where the total of responses to a particular question does not equal the number of useable replies received (40), not all respondents answered the question.

in production. Yet 27 respondents stated the shortage was more acute for engineers to be engaged in research, but only 5 considered it to be more acute for those to be engaged in production. The stated shortage in quantity merely corroborates the general shortage of engineers discussed previously. The stated shortage in quality, however, indicates the need to improve the educational background of engineers to be engaged in aviation armament work. Similarly, the knowledge that the shortage is more acute for those to be engaged in research emphasizes another important consideration for such education.

Additional information obtained from the survey, relative to the shortage of engineers for work in aviation armament, indicates that a definite majority of companies first place newly hired inexperienced engineers on a research team, as opposed to first placing them on production work. Some companies let the personal desires of the new engineers influence this assignment. A number of companies first place newly hired engineers into formal training programs. Such programs as were reported on are generally individual in nature and average about one year in duration. Finally, approximately 77 per cent of the respondents use newly hired inexperienced engineers as sub-professionals, rather than on routine work or in a training program.

The impression received from all this information is that the industry as a whole is attempting to push up the responsibility of the young engineer in order to give him

experience and responsibility at a more rapid rate than has been the case in the past with engineers generally. This undoubtedly results in part from the shortage of engineers qualified for work in aviation armament.

DESIRED EDUCATIONAL BACKGROUND FOR WORK
IN AVIATION ARMAMENT

One of the purposes of the industrial survey questionnaire was to determine the desired educational background for engineers to be engaged in aviation armament work. Buchanan (8, p. 551) states that the representatives of industry and graduate engineers are almost unanimous in suggestions for changes in the education of engineers; "A more thorough grounding in the fundamentals, particularly mathematics and physics; less emphasis on specialized technical fields and greater facility in self-expression, oral and written."

No information on this subject as it applies specifically to armament work could be discovered in the literature. However, one question of the questionnaire states that leading educators are advocating increased emphasis upon basic engineering sciences, and asked respondents if they feel education with such an emphasis would be preferable to the more specialized (i.e., electrical, aeronautical, etc.) types of engineering curricula currently offered. Approximately 90 per cent of the respondents answered "yes" to this inquiry. Typical comments concerning the type of education desired for armament work state, in one way or another, that undergraduate work should be generalized and graduate work specialized.

The particular areas of knowledge that should be incorporated in the curriculum to provide this broad engineering background were also sought, together with some indication of their relative importance. To accomplish this without complicating the questionnaire unnecessarily, respondents were asked to indicate whether a young college graduate should have "a good foundation," "some knowledge," or "little or no knowledge," of each of the following sciences: aerodynamics, ballistics, chemistry, control devices, electricity, mathematics, metallurgy, physics, power electronics, servo mechanisms, and structures (question 12, Appendix B).

In order of their relative importance, respondents indicated "a good foundation" to be desired in electricity, physics, and mathematics, and to only a slightly lesser degree, in servo mechanisms and control devices. "Some knowledge" is desired in structures, aerodynamics, power electronics, and ballistics. Respondents feel that "little or no knowledge" is required in metallurgy and chemistry, taking into account the practical limitations to obtaining an equally good preparation in all subjects listed. Knowledge of mechanical design and computers is also thought to be of value by two or more respondents in each case.

Respondents were also asked: "If engineers could be hired who were specifically trained for armament work, do you think you would be able to use them initially for more

advanced or original work than at present?" To this question, 38 per cent answered "yes," 35 per cent said "probably," 22 per cent were "doubtful," and only 5 per cent answered "no." Educating engineers for work in aviation armament as recommended, then, is definitely desirable in that it would materially improve their utilization by industry.

It was noted in the Introduction that it has been the experience of representatives of the Armament Division of the Bureau of Aeronautics, that engineers for work in aviation armament should possibly have basic academic training which cuts across the boundaries of traditional engineering courses. Through the survey results reported above, we see this confirmed by representatives of the armament industry. Ideally, engineers to be employed in aviation armament work should have a broad engineering background and have at least some knowledge of electricity, physics, mathematics, servo mechanisms, control devices, structures, aerodynamics, electronics, and ballistics. Also, it was determined earlier that companies desire to employ such engineers more for research work than for production. Few, if any, colleges and universities offer a curriculum that makes such education practicable. Furthermore, any thought of establishing a special armament curriculum is completely unrealistic and will not be considered herein.

Probably the nearest approach to the type of educational background which meets the above requirements is that

found in Engineering Science, Engineering Physics, or General Engineering curricula. Although some of these curricula have been rather long established in certain major engineering schools, the number of degrees granted has been relatively insignificant. In many major engineering schools, however, the current trend is to emphasize this type of engineering education. For example, Purdue University, which only recently established an Engineering Sciences curriculum in lieu of a program in Engineering Mechanics, conducted an industrial survey among employers of Purdue engineering graduates, to evaluate the engineering curriculum.

One question of the Purdue survey asked these potential employers: "Do you think there is need for an undergraduate curriculum offering an integrated, across the board type of program with emphasis on the subject matter and methods common to the major fields of engineering?" Fifty-nine per cent of the respondents answered "yes" to this question. Twenty-five per cent did not think there was a need for such a program and the remaining sixteen per cent did not respond to the question. Those who thought there is a need for an integrated program thought that about half of the students should take such a program (18, pp. 5-6). This type of curriculum, then, should receive increasing emphasis by both industry and engineering institutions, and may serve as a source of properly educated young engineers for armament work. In this connection, it is of interest to note

that the Purdue Engineering Sciences curriculum specifically orients students for work in research and development in the various fields of engineering.

Because of the scarcity of engineering graduates who have in the past received the broad engineering background stated as desirable by a majority of the respondents to both the Purdue and armament (thesis) surveys, respondents to the armament survey were apparently thinking only in terms of conventional curricula when they answered questions dealing with desired educational background for armament work (question 9, Appendix B). Predominant types presently employed for aviation armament research are, in order of importance, mechanical and electrical (each noted by approximately 95 per cent of all respondents), and aeronautical and physics (each noted by approximately 45 per cent of all respondents). Fewer responses were received to an ad-

concerning the type of background prefer-
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 amament research. (large corporation)

es to make up a complete project team.

Good basic engineering foundation (probably at B.S. level) plus, where possible, a particular specialty. A relatively small company requires men with a capability in good basic engineering plus a few specialists.

Here again we see emphasized the need for a broad engineering background for people to be engaged in armament work.

RECRUITMENT PROCEDURES AND INDUCEMENTS TO ACCEPT GOVERNMENT EMPLOYMENT

Active and purposive recruitment of engineers for government employment is necessary as a result of the increased demand for engineers in recent years. It should be emphasized that in any attempt to determine the causes which underlie the problems of the Navy in recruiting engineers, it must operate during times of peace in competition with other government organizations and civilian industries requiring similar personnel. Furthermore, the fact that government compensation of engineers is governed by Civil Service pay scales which are currently substantially lower than salaries being offered by industry for identical educational qualifications, makes the competitive position of government difficult indeed.

Before considering difficulties associated with recruitment of engineers for government employment, it is desirable to compare a study of the attitudes of engineers toward government employment with a study of the attitudes of engineers toward industrial employment. Although these studies are by no means conclusive, they are representative and indicate the nature of the problem with which we are concerned.

Attitudes of Engineers Toward Employment
in Government and Industry

In a questionnaire survey conducted by Syracuse University, which was answered by 335 scientists and engineers who left government laboratories in 1948, 46.3 per cent gave as their reason for leaving the "desire for better pay and better opportunities for economic advancement." Although many more persons gave this reason than gave any other, it is of interest to note that a large group of these respondents (36%) did not leave government employment for industry, but instead transferred to other government organizations. In other words, factors adverse to government employment itself did not enter into the decisions of these people to leave their positions, and a large proportion could probably have been retained through better administrative practices. Slightly more than 56 per cent of the respondents were 30 years of age or under, and "approximately 1 out of every 2 respondents who transferred to another government organization or who accepted employment in private industry reported that he went to his new position at a promotion." (1, pp. 16-21).

Thus it may be said that most respondents had limited career experience and that promotions entered into their decisions to leave or transfer from their last government employment. Additional reasons given for leaving government employment, in order of importance, were, desire to live and work in a new location, desire to have further

education, lack of opportunity to do challenging work, dissatisfaction with the competence of supervisors and co-workers, etc.

In a discussion of the above survey by its authors in the May 4, 1951 issue of Science, they make the following comments:

The nature of the questionnaire was such as purposely to bring to the fore a considerable amount of adverse criticism about government employment experience.... Accordingly, it is important to bear in mind that, in an evaluation of their government employment experience, 80 per cent of the respondents indicated they felt that experience had ranged from satisfactory to excellent. This suggested that for the group as a whole there was a decidedly favorable reaction to having worked in government laboratories. (2, p. 506).

The findings did not support a conclusion that the majority of these scientists and engineers left their government positions because of deep-seated dissatisfactions with their employment experience. Indeed, the overall reaction to that experience was favorable, although there were numerous matters about which dissatisfactions were expressed. (2, p. 509).

Now let us compare briefly the above attitudes of engineers toward government employment with those of engineers in industry. A thorough study of the problem of recruitment of engineers for industry was made in 1953, covering 200 companies and 1400 individual engineers by mail questionnaire and field survey (17). Over all, the survey showed that almost half (45%) of the engineers in industry are not satisfied with the amount of their pay and that a third of them (34%) do not feel their prospects for advancement are good. "It showed, too, that approximately 40 per cent of all the engineers in industry are discontented with two or more important aspects of their jobs...." (4, p. 21).

Importance of Recruiting Representatives

The above two surveys indicate that, with the exception of lower salaries paid government engineers under Civil Service, there appear to be few actual differences among reasons for accepting employment in government or in industry. Why, then, is government service not generally considered favorably by a reasonable proportion of engineering graduates? That this is true was confirmed by a study conducted to determine the reason engineering students did or did not apply for U. S. Civil Service Commission examinations in the fall and spring of 1950-51 (10). This study obtained information from questionnaires and interviews of student opinions concerning the advantages and disadvantages of federal and industrial employment. Results of the study indicate that, so far as junior engineers are concerned, the government is in an adverse competitive position, especially to recruit those of greatest talent and ability. It was also found in this study that, in many instances, placement officers and interested students had decidedly unfavorable experience with direct recruitment by federal agency representatives. "The school officials reported that government recruitment officers were often less effective than those for industry, frequently having little knowledge of the job for which they were recruiting."

Effective recruitment of college engineering graduates is essentially a problem in effective communications. One approach to the understanding of college seniors' attitudes

toward federal employment is to examine their sources of information concerning such employment opportunities. A study of this problem determined that although college placement officers proved to be almost equally effective as the source of employment information for both industrial and government jobs, representatives who visit the campus were found to be considerably more effective for industrial job information (30.6%) than for federal job information (13.5%). This was the most important source of information for industrial job opportunities (16, p. 57).

The effective use of well qualified representatives of government agencies for direct recruitment at colleges and universities offers an opportunity for substantial improvement in the number and quality of engineers who accept government employment. As a result of procedures taught in engineering education, engineers analyze employment opportunities carefully and tend to appraise critically all factors that relate to such employment. Consequently, since interviewers are often the only visible evidence the graduate has of the organization with which he may later be employed, and because first impressions are so important, it is vital that the interviewer be carefully selected and trained for recruitment assignments. There is little question that concerted use of effective methods of college recruiting on the part of government agencies, truly competitive with the efforts of industrial representatives, would

contribute substantially to the success of these agencies in employing desired engineering personnel.

Importance of Descriptive Literature

Additional studies of reasons why college students do not apply for government employment in engineering fail to disclose any reasons genuinely unique with federal employment, other than the pay difference already noted, and poor recruitment practices. One study states that "the topic most heavily discussed adverse to Federal employment was its failure to receive good publicity or to publicize its advantages to such an extent that the specific unfavorable views held by the majority of student-engineer applicants would be minimized or eliminated." (9, p. 48). Here possibly is a key to the entire problem. "Federal recruitment literature including announcements and other forms should be examined for their impact upon the student. The effectiveness of distribution, readability of the text, and effectiveness of communication of content should be studied." (16, p. 73).

Finally, some adverse attitudes toward federal employment for engineers are undoubtedly based on at least partial misconceptions concerning conditions of employment in government. However, until these misconceptions are corrected, job decisions will be based on them. This again indicates the need for a better flow of information about federal employment opportunities to engineering students and faculties.

It may be suggested, then, that the job satisfaction experienced by engineers in government does not differ greatly from that of engineers in industry, and that recruitment difficulties arise largely as a result of factors outside the work situation. Among these are lack of adequate publicity favorably describing government employment opportunities, the tendency of engineering graduates to base job decisions on partial misconceptions, and, probably most important of all, inadequacy of government recruitment procedures in general.

Effective Recruiting Techniques

Considerable work has been done to determine effective recruiting techniques. For example, it is extremely desirable that the same representative be assigned to a specific area year after year so that a working liaison can be built up on the basis of mutual understanding (7). A survey of senior engineering students at the University of Texas indicated that pre-interview information could be greatly improved, the interviewer should be a man technically trained, he should know what jobs are currently available, results of interviews should be sent out promptly, and company visits strongly influence students' choices (12). In other words, the recruiter must know what is involved in each job, details of training and further education to be provided, if any, and many other pertinent details. To avoid dissatis-

faction following employment, though, overselling the job should be avoided at any cost.

One study conducted for the Navy by the American Council on Education makes numerous specific suggestions and recommendation for improving the degree of success achieved by the Navy in procuring required scientific personnel (20). Some of these are not too practical in that they require enabling legislation by the Congress, but others are of value currently. The importance of prompt action in hiring is emphasized, and should be noted.

....desired applicants should be invited to submit applications. These, when received, should be acted upon promptly and the selected applicants should be offered employment without delay. One of the chief present causes of failure to secure desired applicants is the delay which elapses between receipt of an application and notification of acceptance, as compared with the time interval that elapses in the case of industrial employment. (20, p. 12).

Many companies have found that one of their most successful techniques is the practice of recruiting top students during their junior year and giving them temporary employment with their engineer group during the summer before they reach their senior year. This not only gives the student a clear conception of the work which will be expected after graduation and the company a chance to evaluate his abilities,...but most important, it insures that the graduate knows what he is getting into when he enters industry, and is prepared for the routine tasks which come along. (5, p. 240).

The use of recruiting brochures, advertising, letters and descriptive literature have also been found to be of value. The above are essentially industry procedures, but indicate what the competitors of government for available engineering talent are doing that is effective. It should be noted that

in summer employment, particularly, the student should be given meaningful work and not be permitted to stand around simply to observe (3).

Inducements to Accept Government Employment

Even after consideration of methods to make government recruitment more competitive with industry, the problem of an inducement to accept government employment sufficient to nullify the higher salaries offered by industry remains unsolved. In instances where an appeal to accept government service is not effective in attracting engineers to government in sufficient numbers, other inducements which make government employment competitively attractive with employment in industry must be provided. "It is generally recognized that many intangible compensations in college and university employment make the positions attractive and must be counted among the inducements to serve on a college staff. From this, one concludes that the management and administration of government laboratories should determine if they cannot offer such inducements." (23).

Some insight into this problem may be gained from a consideration of goals and preferences of graduates when selecting the organization for which they would prefer to work. These have been found to involve several factors which seem to be predominant. The most important consideration is whether a job is available in line with the graduate's interests and training and whether it is a real

career opportunity. A second consideration is the opportunity for training. Whether or not the company or organization is well and favorably known is often important. Another consideration is that many graduates seem to want to locate in or near their home towns. Finally, salaries offered should be within the prevalent range, but it is important to note that salaries are not generally the prime consideration in employment (3, pp. 20-21).

It is apparent, in thinking of these factors in relation to government employment, that only the factor of training or education can be expanded to provide an inducement to accept such employment in preference to more highly paid but similar positions in industry. In all normal placement situations both in government and industry, every effort should be made to fit employees into positions in line with the graduate's interests and training, and offer him an opportunity to move ahead. Also, reputation, location, and starting salaries are all more or less fixed. But education offers an opportunity to provide something extra. Thus, the inducement to accept government employment at the salaries to which government employers are currently limited, and which presently seems to afford the most promise, is that of education.

One of the objectives of this thesis has been stated to be investigation of the desirability of graduate education to assist in qualifying engineers for work in aviation armament. Since there is the possibility that such

education may also be of value as an inducement for engineers to accept government employment, it will be considered from both points of view in the discussion which follows.

DESIRABILITY OF GRADUATE EDUCATION

The term "graduate education," as used herein, refers to thesis research and course work on the graduate level which may be applied toward the requirements for a graduate degree, particularly the Master's degree. Statistics indicate that academic work of this nature is beyond the capacity of many people, or of insufficient interest to them to merit their active participation in a graduate education program. Thus, it is important to bear in mind during any discussion of graduate education that we are no longer concerned with all engineers, either in aviation armament work or elsewhere. "A substantial number of college graduates take some graduate work. For the country as a whole, the number of master's degrees is equal to about 17 per cent of the number of bachelor's degrees conferred 1 year earlier." (26, p. 37). From this it is apparent that a great many engineers never participate in a graduate program.

Studies have shown that of the number of students graduated from college each year, 83 per cent on the average, are judged not competent to go further in graduate work. Of the 17 per cent judged competent to enter graduate study, 6 per cent do not continue for one reason or another, not financial; 4.4 per cent do not continue for lack of funds; and the net result is that 6.6 per cent, or only 40 per cent of those judged competent to enter graduate study, actually do plan to continue (24, p. 14). Disregarding discrepancies

between the above two estimates, we see that the group to whom graduate education should be made available is limited.

No implication is made that a company or government agency should have as its objective that of hiring only "the cream of the crop." However, the need for proper placement of engineers hired is emphasized, as is evaluation of the qualifications of those to be offered advanced education. Considered among these qualifications should be the desires of the individual regarding further education, the extent to which such education would benefit both the employer and the employee, and the interest in and understanding of the technical problems of the organization as evinced by the engineer concerned. Practical leaders want the process of education to be brought to bear upon certain problems after graduates have enough experience to understand the significance of these problems and why it is worth the effort to learn how to solve them (22).

In view of these limiting considerations, it is not surprising that respondents to the industrial survey questionnaire made numerous qualifying comments in answering questions relative to graduate education. There was definite agreement that graduate education is thought to be worth while. Respondents were asked "In general, have engineers possessing the master's degree proved sufficiently more valuable than those possessing only a bachelor's degree to warrant a scholarship or fellowship program to provide the additional year or more of academic work?" The question

is worded to imply some financial participation on the part of the employer in order to solicit answers carefully considered and based on experience.

Twenty-eight organizations answered "yes" to this question, and seven answered "no". That at least some of the respondents did base their answers on experience is indicated by their comments, although comments were not requested in connection with the question. One respondent answering "yes" thought that engineers possessing the master's degree are more valuable, "but not enough to warrant a scholarship at company expense." A respondent answering "no" commented: "Other things being equal, we believe work for the Master's Degree is worth while. However it has not proved so with the limited number of special cases in our experience." In general, a preponderant majority thought graduate work to be sufficiently valuable to warrant financial help.

Respondents were less in agreement and made many more comments in answering questions intended to determine the type of graduate education desired. In this connection, hindsight has shown that the questions through which it was hoped to obtain this information were not properly worded, so that, on this topic at least, the comments are a more reliable guide to the thinking of respondents than are answers to the questions asked.

Some representative comments relative to the type and desirability of graduate education are as follows:

The talented engineer should be given more opportunities to pursue postgraduate studies while employed in industry.

We believe the additional study required for a master's degree increases his knowledge of fundamentals sufficiently to be worth-while.

Our experience has indicated that in terms of accomplishing specific tasks there is no substitute for practical experience. However, with insufficient educational background it is difficult to comprehend modern design technology even with very long experience.

Since ours is a research and development lab (not production) we need radically new and novel ideas. Experience shows these ideas come more frequently from persons broadly trained.

Specialization should be stressed at the graduate level. By that time the individual has had opportunity to scan industry requirements.

It is desirable that the BS graduate have a year or two experience in industry before being exposed to additional broad engineering schooling.

Some idea was desired of the conviction with which respondents thought their suggestions relative to education for work in aviation armament would be of practical value. Accordingly, they were asked to indicate whether or not their organizations would actively seek to employ engineers educated along lines indicated by the survey. To this question, 28 answered "yes" and 8 said they "would make no distinction in hiring." There was but one negative reply, and several respondents indicating "no distinction" qualified their answers.

Apparently, then, specialized graduate education for armament work is definitely desirable, if not essential, and organizations performing such work would actively seek

to employ engineers so trained in preference to those with more conventional education. Comments to questions in the survey have confirmed the observation noted on page 30 that several years' practical experience is desirable before graduate education is made available to qualified engineers.

The value of graduate education has long been recognized by the Navy.

The Navy has traditionally been interested in the growth of its scientific and engineering staff and recognizes that to maintain a well-trained, flexible, and capable force of employees, explicit interest must be shown in their continued development. The Navy's professional development policy emphasizes in-service training to keep scientists and engineers abreast of progress in their special fields, advanced study at universities to improve their competence, and encouragement of activity leading to professional recognition. (11, p. 13).

The value of a graduate education program for engineers was studied recently at the Naval Ordnance Plant, Indianapolis, Indiana (NOPI). This program was conducted at the Plant by professors from Purdue University, half the instruction being given during working hours and half during the participant's free time. The total time required to qualify for the degree of Master of Science in Engineering was approximately four years for those initially holding only a B.S. degree. Participants had been permitted to enroll initially only on the basis of past performance in the Plant; those not doing work of high quality not being permitted to take the course. About 30 employees expected to complete the program.

Fifteen participants in this program were interviewed individually to determine whether or not the course was of sufficient benefit to the Navy to justify its continuation on a regular basis. These interviews were conducted about two months prior to completion of the course. The primary objective of the interviews was to evaluate the education program as an inducement to accept government employment or to prolong the individual's period of employment.

Almost all the people interviewed made reference to the direct benefit of the course to the Navy through increased competence of the participants in their jobs. As a result of conversations with supervisors, this reaction was expected and did not reflect the primary purpose of the interviews. One participant who held a master's degree in engineering before taking the NOPI course said he wanted to broaden his engineering background and be better prepared to handle aspects of his work which he found difficult. This attitude was rather common with most persons interviewed. Replies were surprisingly frank and interviewees appeared willing to discuss the effect of the program in their individual future plans, even when it involved leaving the Ordnance Plant.

As an inducement to accept government employment, the participants felt, in general, that the program was definitely of value in attracting and holding competent engineers. Despite relatively minor support given by the Navy

as compared with similar industrial programs, there was positive evidence that the program was responsible for attracting some engineers to NOPI initially, and in holding others as employees longer than they would normally have remained. No person interviewed thought graduates of the program would seek and accept jobs elsewhere merely as a result of completion of the course. Some did expect their better qualifications to be considered when promotions were being made, and apparently the Plant management agreed with this.

One of the most extensive of government agency programs for graduate education is that of the Naval Research Laboratory, Washington, D.C. A university course program with the University of Maryland, similar to that described above for the Naval Ordnance Plant, Indianapolis is maintained to help the employee substantially in his work and which will also meet the University requirements for an advanced degree. Other programs are also offered which are more advanced.

The program for educational advancement in the physical sciences at the Naval Research Laboratory is a plan whereby graduate students may, as members of the Naval Research Laboratory staff, conduct research leading to advanced degrees at cooperating institutions. Under the plan it is also possible to arrange for course work for graduate credit at universities in the vicinity of Washington.

Through this program the Navy hopes to expand the personnel of the Naval Research Laboratory, in accordance with its growing research program, by attracting to the Laboratory young scientists of promise. It offers to students professional advancement in fields of interest to the Navy and the use of the excellent research facilities of the Laboratory (21).

The success of the Naval Research Laboratory in attracting and holding young scientists and engineers of exceptional ability through these programs has been outstanding. Not all government agencies are so favorably situated or of sufficient size to maintain programs of this scope. However, experience indicates that, to perform most effectively, government agencies should provide educational programs to the maximum extent possible. Opportunities for professional growth and development while engaged in naval laboratories do help to attract and retain engineers of the highest quality.

DEGREE OF ASSISTANCE TO BE PROVIDED ENGINEERS
FOR ADVANCED ACADEMIC WORK

Both this study and others indicate that there is a definite trend in industry and government toward programs designed to encourage graduate education among engineering employees. Investigations relevant to this thesis have verified both the need for and benefits of such programs. However, as has been noted previously (p. 29), there are three reasons why engineers do not participate in programs leading to advanced degrees. These are (1) lack of ability successfully to pursue graduate work; (2) lack of proper interest to make graduate work of mutual benefit to the engineer and his employer; and (3) lack of funds with which to finance such education.

The group with which we will be concerned, essentially, in this discussion, is the group competent to pursue graduate work successfully, but lacking sufficient funds. "Among the thousands of science baccalaureate graduates each year, there are many capable young men and women who would like to continue their scientific training but who do not find it possible to do so because of lack of financial support." (13, pp. 31-32). Studies have shown that practically 100% of all graduate students receive support at some stage of their education (14, p. 26).

There is a growing awareness among industrial consumers of engineering talent of their sense of social

responsibility. As a result, many companies have established industrial scholarships and made university grants, not to mention their active financial support of university-sponsored courses for their professional employees. It is no discredit to these companies to point out that such contributions to education are not entirely philanthropical in nature, but are of long range financial benefit.

Some indication was sought in the industrial survey questionnaire of the extent to which respondents thought financial support of graduate education is desirable for engineers to work in aviation armament. Specifically, they were asked to identify desirable programs for providing the graduate work, and were then asked if the company should pay all costs of such education. More than half of all respondents made qualifying comments in connection with answers to these questions (question 19, Appendix B).

Possible programs were stated to be (a) part time or off hours university extension programs, (b) full time graduate study, and (c) fellowship or scholarship programs. Of the respondents who thought the company should pay all costs of the program, seven indicated their answers applied only to university extension programs, one referred only to full time graduate study, and although the remaining two checked all three possibilities, each listed university extension programs and full time graduate study as most desirable. It is significant that such a large number of respondents

(30 per cent of all who answered this question) thought the company should pay all costs of a graduate education program.

Of the 23 respondents who thought the company should not pay all costs of graduate education programs, responses varied from those which applied only to university extension programs, to those which applied to all three programs suggested. Here again, a considerably greater number of respondents indicated a preference for university extension programs and full time graduate study than desired fellowship or scholarship programs. In general, comments indicated that most companies feel it is desirable to pay only part of the costs in order to leave some requirement to be met by the student who is to benefit from the education. The following comments are representative of the large number received relative to financing graduate education:

Student gets more out of program by investing part of funds himself. "Free" items are seldom appreciated. Company should encourage by paying part.

A requirement for industry to pay educational costs for employees results only from a shortage of experienced employees....Being practical, and in the case of engineering to make the profession attractive, it is probably desirable for industry to provide some assistance but certainly not all.

A yes answer might be more appropriate due to the shortage of engineers. However, the graduate study is of such personal benefit to the individual we believe he should bear some of the expense.

An individual will benefit more from an educational program if he pays for it himself. Companies might pay a part to demonstrate their interest or to relieve the student of too great a financial burden.

This company presently pays 50% leaving some requirement for incentive from the employee.

I do not believe the effectiveness of the program is dependent upon "who pays." To the extent that advanced education means specialization and that is primarily beneficial to industry, industry has the largest stake in the program with attendant obligations.

If the company pays only a part of the costs only the persons really interested will take the program.

It is apparent from these survey results that companies engaged in armament work not only feel graduate programs are desirable, but that the companies expect to pay part of the costs. The contribution toward such programs usually mentioned in the comments was 50 per cent. Some companies offer doctoral or post-doctoral fellowships as part of a comprehensive professional development program, but these are the exception rather than the rule and are economically unfeasible for most organizations. This is true in government as well as in industry.

Graduate education programs of the Naval Research Laboratory, referred to on page 35, include a post-doctoral research associateship program which provides stipends of \$5940 for each of ten young investigators of unusual ability who hold the Ph.D. or Sc.D. degree. However, the programs of value to most engineering employees (and to the Naval Research Laboratory as well) involve university courses and thesis research for the Master's degree. These courses are scheduled to meet so that half the class time is during working hours and the other half is after working

hours. The regular tuition fees are paid by the employees although NRL secures annually from the Secretary of the Navy, authority to give financial support to university courses which are undersubscribed.

To accomplish thesis research, NRL usually obtains approval from the University concerned for the employee to conduct off-campus research, pointing out the excellent research facilities and scientific counsel available at NRL. In other cases it is advisable for the employee to save his annual leave and with additional leave granted without pay, spend one year at his chosen university. It should be appreciated that, in the latter case, NRL makes a real contribution even though the employee is on leave without pay, through its acceptance of dislocations which inevitably result from extended absences of qualified personnel.

Costs of the program described on page 33, which has been in effect at the Naval Ordnance Plant, Indianapolis, are also borne by the participating employees, the Ordnance Plant merely giving financial support to courses which are undersubscribed. During interviews at the plant, six or seven participants commented on the considerable benefit the Navy thus derives from an extremely minor investment. There was no evidence of resentment in these comments, most of these same interviewees also mentioning the considerable benefit of the program to themselves. On the other hand, several interviewees said they

felt justified in leaving whenever they desired since they didn't "owe" the Navy anything. These comments and others indicate that employees feel obligated to repay the employer through continued service, more or less in proportion to the employer's investment in their training and education.

Engineers at the Naval Ordnance Plant were anxious to discuss the value to the Navy of helping selected engineers do full time graduate work at a university, where a more individual program could be followed. This may be the only type of program feasible for professional employees at many naval activities not conveniently located relative to suitable educational facilities, or not possessing the exceptional research facilities of NRL. Specifically, it was suggested that employees be allowed to go full time for one term each year. Furthermore, the employees felt that if such a program were to be effective as an inducement to attract promising engineers to accept employment at the Plant, they should be paid during time spent at the University, but at no more than one half the regular salary.

By granting sabbatical leave, leading universities have, for many years, offered both leave and financial assistance to professors desiring to do further academic work. This is common practice, and such a use of public funds (in the case of land grant colleges and universities) is not questioned. As a minimum measure of assistance, naval activities could compensate engineers performing full

time graduate work in accordance with a similar plan. On this basis, an engineer could be granted leave at the end of six years for one semester of study at full pay, or for two semesters at one-half pay. Similarly, at the end of only three years, he could be granted leave for one semester of study at one-half pay, or for two semesters at one-quarter pay. He could, of course, use annual leave at full pay during part of this time in either case.

The policy of many government agencies has been to avoid any graduate education programs requiring more than minimum contributions of government funds. This reluctance to "educate civilian engineers at government expense" is probably understandable from the political point of view. Substantial government agency contributions toward graduate education of promising engineers can be justified on the basis of any other consideration.

In such fields as armament work, where results of the survey reported on herein indicate graduate education is particularly desirable, naval activities should offer opportunities for such education that are competitive with those of armament contractors in industry. Otherwise, many of the better qualified engineers will be lost to industry and Navy programs will inevitably suffer. This seems particularly true in consideration of the Civil Service salaries to which all government organizations are restricted.

No suggestion is made that naval activities contribute financially toward graduate education of all their engineers. Newly hired engineering graduates should be placed carefully and then required to work for several years before being offered an opportunity to do graduate work involving substantial financial support. Although engineers of promise and ability will usually be known by that time, tests are available to assist in their selection (15) (25). Such practices should assure that opportunities for professional growth and development while engaged in naval laboratories will help to attract and retain engineers of the highest quality in numbers needed for armament work in the Navy.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Important conclusions relative to the education and recruitment of engineers for work in aviation armament may be summarized as follows:

1. There has been and is a shortage of engineers for this type of work. It occurs in respect both to quality and quantity, and is more acute for engineers to be engaged in research.
2. A majority of companies desire younger, inexperienced engineers, as does the Navy, but not to the exclusion of experienced people.
3. On the undergraduate level, education is desired with increased emphasis upon basic engineering sciences to provide a broad engineering background. Both in education and industry, more emphasis is being placed on this type of undergraduate curriculum.
4. Ideally, for work in aviation armament, a young college graduate should have a good foundation in electricity, physics, and mathematics, and at least some knowledge of servo mechanisms, control devices, structures, aerodynamics, electronics, and ballistics.
5. With the exception of the lower salaries paid government engineers under Civil Service, there appear to be few actual differences among reasons for accepting employment in government or in industry.
6. Direct campus recruitment by government agency representatives is much less effective than that of industrial representatives, and can be considerably improved, as can literature describing government employment opportunities.
7. Recruitment and employment of junior year engineering students during the summer has proved to be a successful recruiting technique in industry that may be adopted effectively by naval activities.

8. Several years' practical experience is desirable before graduate education is made available to qualified engineers in armament work. Such graduate education is definitely desirable, and should be specialized.
9. Graduate education programs which offer engineers working in naval activities an opportunity to pursue studies leading to advanced degrees, do help to attract and retain people of promise and ability.
10. Companies engaged in armament work not only feel graduate education programs are desirable, but expect to pay a substantial portion of the costs. The most common programs for graduate education are (1) part time or off hours university extension programs, and (2) full time graduate study.
11. Naval activities make only minor contributions toward graduate education programs, compared to the practices of many industrial firms.
12. Engineers to be offered full time graduate education should be selected carefully. Tests are available to assist in this selection.

Recommendations

1. For work in aviation armament, every effort should be made to recruit engineers with a broad undergraduate background having a good foundation in electricity, physics, and mathematics, and, if possible, at least some knowledge of servo mechanisms, control devices, structures, aerodynamics, electronics, and ballistics. It is desirable that these people express a preference or display an aptitude for research and developmental work.
2. Only carefully selected representatives should be used for direct campus recruiting by naval activities. These representatives should be technically trained men who know details of specific jobs that are available, and other conditions of employment. To be competitive with industrial representatives, they must be trained in the use of effective recruiting techniques.

3. Naval activities should provide adequate publicity favorably describing employment opportunities. Recruitment literature of all types should be examined to insure effective distribution, readability, and effective communication of content.
4. Temporary employment can and should be offered junior year engineering students the summer before they reach their senior year. Transportation to the place of employment should be provided, if possible, and the student should be assigned meaningful work. Continued interest in his progress must be demonstrated during this employment.
5. Applications for employment, when requested and received, must be acted upon promptly, and selected applicants should be offered employment without delay.
6. To increase the engineering capability of the organization and to provide an inducement for capable engineers to accept employment, naval activities should offer part time or off hours graduate education programs for selected engineers to the maximum extent possible. In order to be effectively competitive with industry, these activities should pay approximately one half the costs of such programs.
7. After several years' employment, carefully selected engineers of promise and ability should be offered full time graduate education in fields of interest to the Navy. During this time they should be granted leave and be paid a substantial portion of their regular salary. Such programs should lead to the awarding of advanced degrees.

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APPENDICES

Appendix A

The industrial survey questionnaire used to obtain information for this thesis, together with examples of the covering letters through which its purpose was explained to organizations contacted, are presented in this Appendix. Two slightly different versions of the covering letter were used; one for industrial organizations (example page 54), and the other for educational and governmental organizations (example page 55). These letters were individually typed, and addressed to a person on the vice-presidential level of the organization who was expected to have knowledge of the individual within the organization best qualified to complete the questionnaire.



PURDUE UNIVERSITY
DEPARTMENT OF GENERAL ENGINEERING
LAFAYETTE, INDIANA

54

March 18, 1955

Dear Sir:

We are undertaking a study, endorsed by the Navy Bureau of Aeronautics, to determine the educational background desired for engineers to be properly qualified for work in aviation armament, and to suggest methods for their recruitment. Because armament work requires education which cuts across the boundaries of traditional engineering curricula, it is felt that no present engineering college graduate will have received adequate training in all of the fundamentals which he should possess in order to do this work. Both the Navy and industry could profitably employ people in the age bracket of 21-30 who are properly qualified academically.

A survey questionnaire, attached, is being used to gather data pertinent to the above problem. Although the Bureau of Aeronautics did not originally sponsor this work, it strongly endorses the investigation and has supplied a list of contractors engaged in armament work. This survey questionnaire will be of value to the Navy and to its contractors such as your own company only insofar as your answers indicate your needs. One purpose of the questionnaire is to help you.

Will you please refer the questionnaire, together with this letter, to the individual in your organization most directly concerned with the problem of obtaining competent technically trained engineers for your armament work? Even if you are not now conducting such work, your answers to such questions as are appropriate to your possible future needs will be of value and are solicited. Results of the study will be made available to respondents, if desired. You may be assured that your company's name will not be used or disclosed in any way.

Thank you very much for your assistance.

Respectfully yours,

J. A. Ritchey
Assistant Professor
Industrial Engineering

PURDUE UNIVERSITY
DEPARTMENT OF GENERAL ENGINEERING
LAFAYETTE, INDIANA

55

March 18, 1955

Dear Sir:

We are undertaking a study, endorsed by the Navy Bureau of Aeronautics, to determine the educational background desired for engineers to be properly qualified for work in aviation armament, and to suggest methods for their recruitment. Because armament work requires education which cuts across the boundaries of traditional engineering curricula, it is felt that no present engineering college graduate will have received adequate training in all of the fundamentals which he should possess in order to do this work. Both the Navy and industry could profitably employ people in the age bracket of 21-30 who are properly qualified academically.

A survey questionnaire, attached, is being used to gather data pertinent to the above problem. Although the Bureau of Aeronautics did not originally sponsor this work, it strongly endorses the investigation and has supplied a list of contractors engaged in armament work. In general, the questionnaire is oriented toward industry, but the information requested is also desired from certain educational and research organizations. We are using the same questionnaire for all organizations contacted in order to compare the results from these different sources.

Will you please refer the questionnaire, together with this letter, to the individual in your organization most directly concerned with the problem of obtaining competent technically trained engineers for your armament work? Even if you are not now conducting such work, your answers to such questions as are appropriate to your possible future needs will be of value and are solicited. Results of the study will be made available to respondents, if desired. You may be assured that your company's name will not be used or disclosed in any way.

Thank you very much for your assistance.

Respectfully yours,

J. A. Ritchey
Assistant Professor
Industrial Engineering

Engineers for Armament Work
Purdue University Survey

This survey questionnaire will be of value to the Navy and to its contractors such as your own organization only insofar as your answers indicate your true needs. If you feel an answer needs clarification, make additional comments as desired. All comments and suggestions are welcome. Attach a separate sheet, if necessary, making reference to the question concerned. Please insure that all entries are legible. Remember, one purpose of this questionnaire is to help you.

In completing the questionnaire, apply the term "armament" not only to weapons and control systems but also to the technological improvements developed for devices, processes, and techniques useful to the Navy Bureau of Aeronautics in such applications as guided missile work, etc. In cases where this definition does not sufficiently identify armament work within a particular organization, consider "armament" to include any work for the Bureau of Aeronautics either as prime contractor or as a sub contractor.

In general, this questionnaire is concerned with inexperienced graduates of engineering schools, who have been awarded no more than the master's degree.

1. Name of company: _____

Year established: _____

2. Approximate total number of employees (in your division only): _____

How many of these are engineers? _____

3. Approximately what percentage of the company's total business is devoted to work in aviation armament as defined above? _____

4. Approximately how many of the engineers referred to in question 2 are engaged in

(a) armament research? _____

(b) armament production? _____

5. Do you prefer to hire younger men with little or no experience but a good educational background and train them for advanced work in your organization, or are you interested primarily in experienced personnel?

(Check one)

_____ (a) younger college graduates

_____ (b) experienced engineers

_____ (c) both more or less equally

_____ (d) other (specify)

6. During the past year, has your company experienced a shortage of engineers for your armament work as defined above? Yes _____ No _____

If your answer is "yes", is this shortage one of

_____ (a) quality _____ (b) quantity _____ (c) both

Is the shortage more acute for engineers to be engaged in

_____ (d) research _____ (e) production

7. In general, are newly hired inexperienced engineers

_____ (a) first placed on production work

_____ (b) first placed on a research team

_____ (c) either (a) or (b) depending upon educational background

_____ (d) other (specify)

8. If newly hired inexperienced engineers are first placed in research, do they

_____ (a) perform routine work, mostly of a paper nature (engineering assistant)

_____ (b) work as subprofessionals to handle the detail work for top engineering men (involves technical work)

_____ (c) enter a formal training program

If answer is (c), please comment as to length, purpose and type of training:

9. What are the predominant types of educational background of the aviation armament research engineering personnel presently employed? (Check 1, 2, or 3 answers)

☐ (a) aeronautical
☐ (b) civil (structures)
☐ (c) electrical
☐ (d) engineering science or general engineering
☐ (e) mechanical
☐ (f) mathematics
☐ (g) physics
☐ (h) other (specify)

What type background do you prefer?

Please comment as to the basis of your preference:

10. What are the desired types of educational background for engineers to be engaged in aviation armament production? (Enter letter designations from the list of question 9).

11. Do you transfer or alternate assignment of young engineers between research and production activities?
 Yes _____ No _____

If "yes", is this to

☐ (a) give them experience
☐ (b) place them permanently most suitably

12. In answering this question, please keep practical possibilities in mind; i. e., it is improbable that an individual will have an equally good preparation in all subjects listed, no matter how desirable this may be.

For work in aviation armament, as defined at the beginning of the questionnaire, a young college graduate should have knowledge of the following as indicated: (Code 1 if "a good foundation"; 2 if "some knowledge" and 3 if "little or no knowledge".)

☐ (a) aerodynamics	☐ (g) metallurgy
☐ (b) ballistics	☐ (h) physics
☐ (c) chemistry	☐ (i) power electronics
☐ (d) control devices	☐ (j) servo mechanisms
☐ (e) electricity	☐ (k) structures
☐ (f) mathematics	☐ (l) other (specify)

13. If engineers could be hired who were specifically trained for armament work, do you think you would be able to use them initially for more advanced or original work than at present?

Yes _____ Probably _____ Doubtful _____ No _____

14. Leading educators are advocating increased emphasis upon basic engineering sciences. Do you feel education with such an emphasis would be preferable to the more specialized (i. e., electrical, aeronautical, etc.) types of engineering curricula currently offered? Yes _____ No _____

If "no", please comment, and then omit questions 15 and 16.

15. If your answer to question 14 indicates that you believe a broad engineering background is desirable for work in aviation armament, would you prefer to have this achieved
 _____(a) on the undergraduate level
 _____(b) on the graduate level leading to the master's degree?

Please comment:

16. If the broad engineering background is to be achieved on the graduate level leading to the master's degree, which conventional curricula would provide an acceptable foundation? (Check one or more)
 _____(a) BS Engineering
 _____(b) Bachelor of Engineering Science
 _____(c) Aeronautical Engineering (BS)
 _____(d) Civil (structures) (BS)
 _____(e) other (specify)
17. If a program of study were available to educate people for aviation armament work along lines indicated by results of this survey, do you think your organization would actively seek to employ such people in preference to engineers with more conventional education?
 Yes_____ No_____ Would make no distinction when hiring_____.
18. In general, have engineers possessing the master's degree proved sufficiently more valuable than those possessing only a bachelor's degree to warrant a scholarship or fellowship program to provide the additional year or more of academic work? Yes_____ No_____
19. In attempting to obtain the greatest benefit for your organization, which of the following would you consider desirable programs for providing the graduate work referred to in question 18? (Number in order of preference if you answer more than one, with 1 most desirable).
 _____(a) Part time or off hours university extension programs (require from 2 to 5 years for a BS engineering graduate to qualify for the master's degree).
 _____(b) Full time graduate study (probably within 3 years of initial employment following graduation).
 _____(c) Fellowship or scholarship (may choose to accept other employment than with company providing funds).

Do you think the company should expect to pay all costs of such education if the program is to be effective?
 Yes_____ No_____

If "no", please comment:

20. Would you like a summary of the results of this survey? Yes_____ No_____

Name of the individual to whom results should be addressed:

Professor J. A. Ritchey

Heavilon Hall

Purdue University

Lafayette, Indiana

Appendix B

The following is a summary of replies to each question of the industrial survey questionnaire (see Appendix A), commencing with question 5. For convenience of the reader, the questions are repeated as they appear in the questionnaire, with the total of replies entered for each answer requested.

Pertinent information and observations follow each question to which they apply under the heading "remarks." Statements made by respondents in connection with answers to any question, are quoted under the heading "comments." For questions that have more than one part, letters in parentheses refer to the part of the question in connection with which the comment was made. Not all comments received are quoted.

Where the total of responses to a particular question does not equal the number of useable replies received (40), not all respondents answered the question.

5. Do you prefer to hire younger men with little or no experience but a good educational background and train them for advanced work in your organization, or are you interested primarily in experienced personnel?
(Check one)

4 (a) younger college graduates
4 (b) experienced engineers
30 (c) both more or less equally
0 (d) other (specify)

Remarks:

Three of the four companies checking (b) were established in the 1950s.

Comments:

(b) Experienced engineers, because recent expansion did not permit training time.

(c) Normally, with a nucleus of experienced engineers, would prefer hiring younger men and bringing them up in the business. At present time both types are short in supply.

(c) Lately have been forced to go to more experienced people.

(c) This depends on the manpower situation. Normally, we expect to feed in at the bottom.

6. During the past year, has your company experienced a shortage of engineers for your armament work as defined above? Yes 36 No 2

If your answer is "yes", is this shortage one of
6 (a) quality 2 (b) quantity 28 (c) both

Is the shortage more acute for engineers to be engaged in
27 (d) research 5 (e) production

7. In general, are newly hired inexperienced engineers
4 (a) first placed on production work
16 (b) first placed on a research team
11 (c) either (a) or (b) depending upon educational background
8 (d) training program, 4; design drafting, 2; test department, 1; "depends on work load," 1.

Comment:

(c) and personal choice of new engineer.

8. If newly hired inexperienced engineers are first placed in research, do they
- 3 (a) perform routine work, mostly of a paper nature (engineering assistant)
 - 27 (b) work as subprofessionals to handle the detail work for top engineering men (involves technical work)
 - 5 (c) enter a formal training program

If answer is (c), please comment as to length, purpose and type of training

1. Length - 1 year.
Purpose - Indoctrination; technical development; interest development; aptitude detection.
Type - Rotation; lectures; learning by doing.
2. One year including 6 months job rotation, weekly technical lectures covering whole field of automatic instrumentation and weekly conferences including conference leader training, counseling, etc.
3. 12-18 months depending upon the experience of the individual. Each program is individual in nature.

9. What are the predominant types of educational background of the aviation armament research engineering personnel presently employed? (Check 1, 2, or 3 answers)

- 15 (a) aeronautical
- 2 (b) civil (structures)
- 31 (c) electrical
- 4 (d) engineering science or general engineering
- 32 (e) mechanical
- 6 (f) mathematics
- 15 (g) physics
- (h) other (specify)

What type background do you prefer?

mechanical, 16; electrical (with electronics), 16;
aeronautical, 7; engineering science, 7; physics, 5.

Please comment as to the basis of your preference:

1. We consider that the broadest engineering and physical sciences background is preferable even for the most specialized armament research.
2. Unless backed by experience, none of the above is adequate, by itself. Hence no real preference. Any of the 3 checked (aero., elect., mech.) can

eventually become useful. Most of our work involves application of the 3 fields checked.

3. We need personnel with all backgrounds listed above. To be successful all these background talents must be integrated organizationally to focus appropriate background on given problem.
4. Electrical engineers seem more able to acquire the knowledge involved in other phases of engineering.
5. Good basic engineering foundation (probably at B.S. level) plus, where possible, a particular specialty. A relatively small company requires men with a capability in good basic engineering plus a few specialists.
6. We need all types to make up a complete project team.

10. What are the desired types of educational background for engineers to be engaged in aviation armament production? (Enter letter designations from the list of question 9).

<u>8</u>	(a) aeronautical
<u>2</u>	(b) civil (structures)
<u>18</u>	(c) electrical
<u>8</u>	(d) engineering science or general engineering
<u>25</u>	(e) mechanical
<u>1</u>	(f) mathematics
<u>6</u>	(g) physics
<u>3</u>	(h) industrial

11. Do you transfer or alternate assignment of young engineers between research and production activities?
Yes 15 No 20

If "yes", is this to

<u>13</u>	(a) give them experience
<u>7</u>	(b) place them permanently most suitably

Remarks:

Five of the respondents checked both (a) and (b).

12. In answering this question, please keep practical possibilities in mind; i.e., it is improbable that an individual will have an equally good preparation in all subjects listed, no matter how desirable this may be.

For work in aviation armament, as defined at the beginning of the questionnaire, a young college graduate should have knowledge of the following as indicated:

(Code 1 if "a good foundation"; 2 if "some knowledge"; and 3 if "little or no knowledge".)

<u>2.0</u>	(a) aerodynamics	<u>2.5</u>	(g) metallurgy
<u>2.1</u>	(b) ballistics	<u>1.2</u>	(h) physics
<u>2.7</u>	(c) chemistry	<u>2.1</u>	(i) power electronics
<u>1.5</u>	(d) control devices	<u>1.5</u>	(j) servo mechanisms
<u>1.2</u>	(e) electricity	<u>1.8</u>	(k) structures
<u>1.2</u>	(f) mathematics	<u> </u>	(l) other (specify)

Remarks:

1. In accordance with the code specified in the question, answers indicate a straight numerical average of 33 useable replies to this question. If a respondent failed to code all subjects listed, the reply was not tabulated.
2. Additional subjects listed under (l) other, were: mechanical design (listed 4 times); computers (listed twice); and telemetering, electronics, optics, and oral and written expression (each listed once).
13. If engineers could be hired who were specifically trained for armament work, do you think you would be able to use them initially for more advanced or original work than at present?
Yes 14 Probably 13 Doubtful 8 No 2
14. Leading educators are advocating increased emphasis upon basic engineering sciences. Do you feel education with such an emphasis would be preferable to the more specialized (i.e., electrical, aeronautical, etc.) types of engineering curricula currently offered? Yes 33 No 4

If "no", please comment, and then omit questions 15 and 16.

Comments:

1. If reference is to undergraduate work we believe it should be generalized. Graduate work should be specialized.
2. Provided graduate instruction is given in specialized fields of which there would, of course, have to be very many. (reply based on "yes" answer)
3. No substitute for a good foundation. Specialization should come later and will be more effective.
4. Yes - for project work; No - for research and development.

15. If your answer to question 14 indicates that you believe a broad engineering background is desirable for work in aviation armament, would you prefer to have this achieved

26 (a) on the undergraduate level
6 (b) on the graduate level leading to the master's degree?

Please comment:

1. The talented engineer should be given more opportunities to pursue postgraduate studies while employed in industry.
2. Since ours is a research and development lab (not production), we need radically new and novel ideas. Experience shows these ideas come more frequently from persons broadly trained.
3. The broad engineering background should be achieved on the undergraduate level to inculcate as soon as possible in the engineer's education an awareness of all fields of engineering. This should enable them to be more adaptable to technical developments in all phases of aviation armament work.
4. It is desirable that the BS graduate have a year or two experience in industry before being exposed to additional broad engineering schooling.
5. Specialized training on the job to a large extent can replace graduate training.
6. Our experience has indicated that in terms of accomplishing specific tasks there is no substitute for practical experience. However, with insufficient educational background it is difficult to comprehend modern design technology even with very long experience.
7. Broad undergraduate and specialization at the graduate level. (Numerous comments similar to this.)
8. I believe graduate work should be encouraged on an evening basis after the engineer is in industry.
9. A 5th year should be added to the individual's undergraduate program.

10. We believe the additional study required for a Masters degree increases his knowledge of fundamentals sufficiently to be worthwhile.
16. If the broad engineering background is to be achieved on the graduate level leading to the master's degree, which conventional curricula would provide an acceptable foundation? (Check one or more)
- 14 (a) BS Engineering
 - 12 (b) Bachelor of Engineering Science
 - 7 (c) Aeronautical Engineering (BS)
 - _____ (d) Civil (structures) (BS)
 - _____ (e) other (specify): physics, 3; mechanical, 2; electrical, 2; mathematics, 1.

Remarks:

Possible answers for this question should have included more of the conventional curricula. Results are therefore not reliable. Respondents in many cases failed to answer the question rather than specify curricula not listed.

17. If a program of study were available to educate people for aviation armament work along lines indicated by results of this survey, do you think your organization would actively seek to employ such people in preference to engineers with more conventional education?

Yes 28 No 1 Would make no distinction when hiring 8.

18. In general, have engineers possessing the master's degree proved sufficiently more valuable than those possessing only a bachelor's degree to warrant a scholarship or fellowship program to provide the additional year or more of academic work? Yes 28 No 7

Comments:

1. Other things being equal, we believe work for the Master's degree is worth while. However it has not proved so with the limited number of special cases in our experience.
 2. They are more valuable but not enough to warrant a scholarship at company expense.
 3. Yes for advanced design and research - No for production.
19. In attempting to obtain the greatest benefit for your organization, which of the following would you consider desirable programs for providing the graduate work

referred to in question 18? (Number in order of preference if you answer more than one, with 1 most desirable).

- _____ (a) Part time or off hours university extension programs (require from 2 to 5 years for a BS engineering graduate to qualify for the master's degree).
- _____ (b) Full time graduate study (probably within 3 years of initial employment following graduation).
- _____ (c) Fellowship or scholarship (may choose to accept other employment than with company providing funds).

Breakdown of replies showing the preference of respondents for each answer:

- (a) Most desirable for 25 respondents; second preference of 4.
- (b) Most desirable for 12 respondents; second preference of 5.
- (c) Second preference of 3 respondents; third preference of 7. No respondents thought answer (c) to be the most desirable of the three listed.

Do you think the company should expect to pay all costs of such education if the program is to be effective?

Yes 10 No 23

If "no", please comment:

1. In special cases, the Company will pay all costs. In the general case, the Company will reimburse tuition costs for courses completed with better than average grades. Time off from work for class attendance is also permitted.
2. Student gets more out of program by investing part of funds himself. "Free" items are seldom appreciated. Company should encourage by paying part.
3. A requirement for industry to pay educational costs for employees results only from a shortage of experienced employees....Being practical, and in the case of engineering to make the profession attractive, it is probably desirable for industry to provide some assistance but certainly not all.
4. A yes answer might be more appropriate due to the shortage of engineers. However, the graduate study is of such personal benefit to the individual we believe he should bear some of the expense.



5. An individual will benefit more from an educational program if he pays for it himself. Companies might pay a part to demonstrate their interest or to relieve the student of too great a financial burden.
6. Our educational program provides for reimbursement of 75% of tuition costs. I believe this is entirely suitable as an incentive.
7. This company presently pays 50% leaving some requirement for incentive from the employee.
8. I do not believe the effectiveness of the program is dependent upon "who pays". To the extent that advanced education means specialization and that is primarily beneficial to industry, industry has the largest stake in the program with attendant obligations.
9. Our program pays two-thirds total tuition rather than 100% tuition refund. It has worked out very well in the past few years.
10. An industrious employee would do it with partial help.
11. Yes, but only on satisfactory completion of the program.
12. If the company pays only a part of the costs only the persons really interested will take the program.
20. Would you like a summary of the results of this survey?
Yes 40 No 0

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